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Herbicide Resistant Weeds

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Herbicide Resistant Weeds

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The development of herbicide resistant weeds is described along with strategies to prevent development.

The Scenario

You have been using a trusted herbicide for several years to control weeds plaguing your field. The herbicide works great and you like the comfort of using a familiar and reliable product. Last year you noticed that a certain weed species had more escapes than usual, but you assumed it was due to environmental conditions or application error. This year you sprayed the same herbicide, but instead of a few escapes, your whole field is infested with the weed. Barring a mixing or application error, you could have a herbicide-resistant weed.

What is herbicide resistance?

Herbicide resistance refers to plants within a weed species that, after repeated use of a herbicide, are no longer controlled by normal rates of that herbicide *(Figure 1)*. An example of the development of herbicide resistance is represented in shattercane. As a species, shattercane is effectively controlled by Beacon herbicide; however, a few plants survive normal Beacon rates. These plants produce seeds that germinate the next year. This second generation of shattercane also survives the normal Beacon rate and produces seed, continuing the spread of herbicide-resistant plants.

Several characteristics describe a herbicide-resistant weed:

1. The original species (wild type) is effectively controlled by a specific herbicide.
2. The herbicide-resistant plants within this species are not controlled by this herbicide at the normal usage rate.
3. Resistant plants produce viable seed, which generate additional plants not controlled by this herbicide

Figure 1. Seeds collected from one head of susceptible shattercane and one head of what was believe to be resistant shattercane were planted and then treated with twice the labeled rate of Beacon. The front row indicates a normal shattercane response to the herbicide application while the top row shows response in a resistant shattercane.

Sometimes the term "tolerance" is confused with "resistance"; however, tolerance refers to a species whose wild type is not controlled by the herbicide. For example, shattercane is naturally tolerant to 2,4-D, because shattercane was never controlled by 2,4-D.

What are herbicide mode of action and site of action? Why are they important to resistance?

Mode of action (MOA) generically refers to how a herbicide kills a plant and site of action (SOA) refers to the exact plant function that is disrupted by a herbicide (see *Figure 2*). For example, the herbicides Pursuit and Liberty both stop the production of amino acids in plants by attacking and inhibiting enzymes. Both of these herbicides have the same mode of action (called amino acid synthesis inhibition); however, Pursuit and Liberty inhibit different enzymes, so they have different sites of action. This becomes important because a plant that is resistant to Pursuit, likely is not resistant to Liberty. Following the same idea, Pursuit and Beacon have the same site of action (acetolactose synthesis [ALS] inhibitors), so a plant resistant to Pursuit has a good chance of

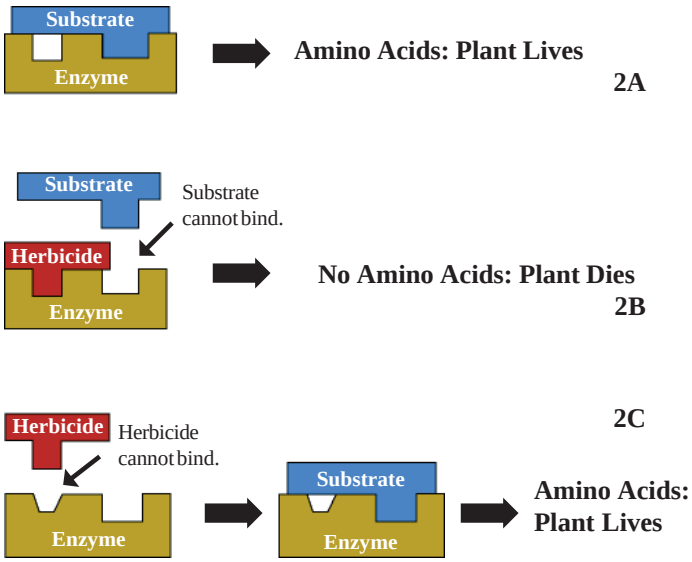


Figure 2. Normal activity of an enzyme substrate complex (2A). Herbicide binding to the enzyme and preventing normal action (2B). The enzyme in a herbicide resistant plant that can't bind with the herbicide (2C).

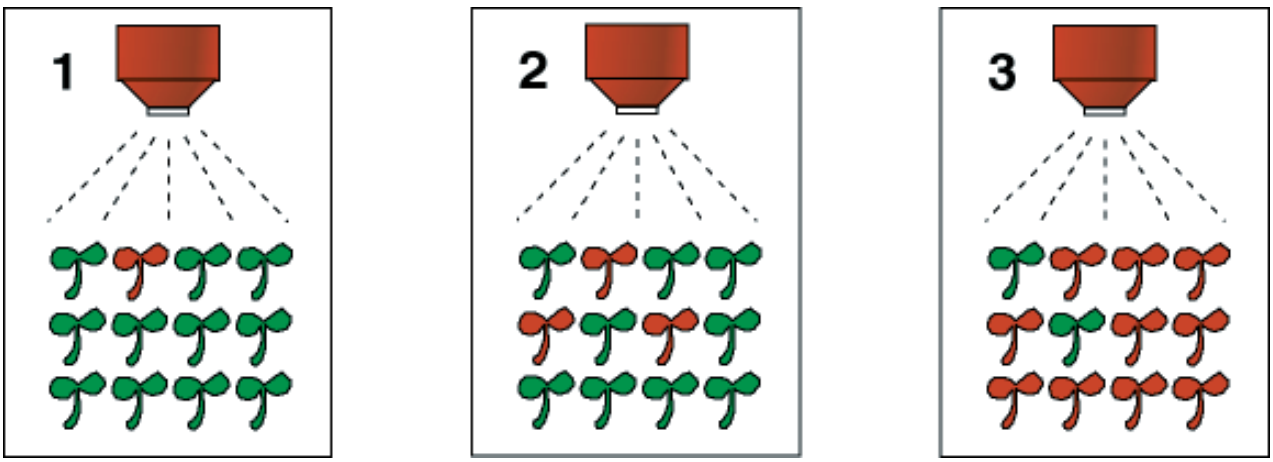
being resistant to Beacon. For this reason herbicides with the same site of action are grouped together. The NU Cooperative Extension Circular, *A Guide for Weed Management in Nebraska, EC130*, lists herbicides and their mode and site of action groupings.

How do herbicide-resistant weeds develop?

Most weed species are able to adapt to changes in the environment. For example all waterhemp plants look similar to each other, but some plants germinate earlier in the spring while others produce more seed, flower early or perhaps prefer more moisture. When a farmer grows corn in an irrigated field for several years, he is probably selecting for those waterhemp plants that grow best under irrigation. Similarly, if a farmer uses the same herbicide site of action for several years in a row, he is selecting for waterhemp plants that are not controlled by that herbicide.

Herbicide resistance often develops in fields that have been sprayed with herbicides with the same site of action for several years. ALS herbicide-resistant shattercane became prevalent in fields that were treated with ALS-inhibiting herbicides for at least five years in a row. Triazine-resistant waterhemp developed in fields where atrazine has been used for several consecutive years. ALS herbicide-resistant Powell amaranth and common waterhemp developed in Kansas after three years of exposure to ALS-inhibiting herbicides.

Herbicide resistance is usually attributed to slight genetic differences between resistant and susceptible plants. These changes occur at a frequency of one plant in a million or even a billion. Within a 160-acre field, only one or two plants may be genetically resistant to one herbicide site of action (see *Figure 3*). After using this herbicide site of action for several years, the susceptible weed population is reduced and the resistant plants increase in number. By the fourth or fifth year of applying the same herbicide site of action, the resistant plants dominate a field and the farmer observes "herbicide failure" (see *Figure 4*). No one knows which weed species or fields possess the herbicide-resistant plants; however, the potential is present. Using the same herbicide site of action each year increases the probability of developing a herbicide-resistant weed population.



1 Resistance development begins with one resistant plant in a field. When sprayed with the herbicide, the resistant plant lives and reproduces while most of the susceptible plants die.

2 The next year more resistant plants are present in the weed population. Spraying the same herbicide site of action kills most of the susceptible plants, but the resistant plants survive and reproduce.

3 Several years of this practice and the resistant plants finally dominate the weed population and the field.

Figure 3. Steps show the increase of a population of herbicide-resistant weeds in a field receiving an annual herbicide application.

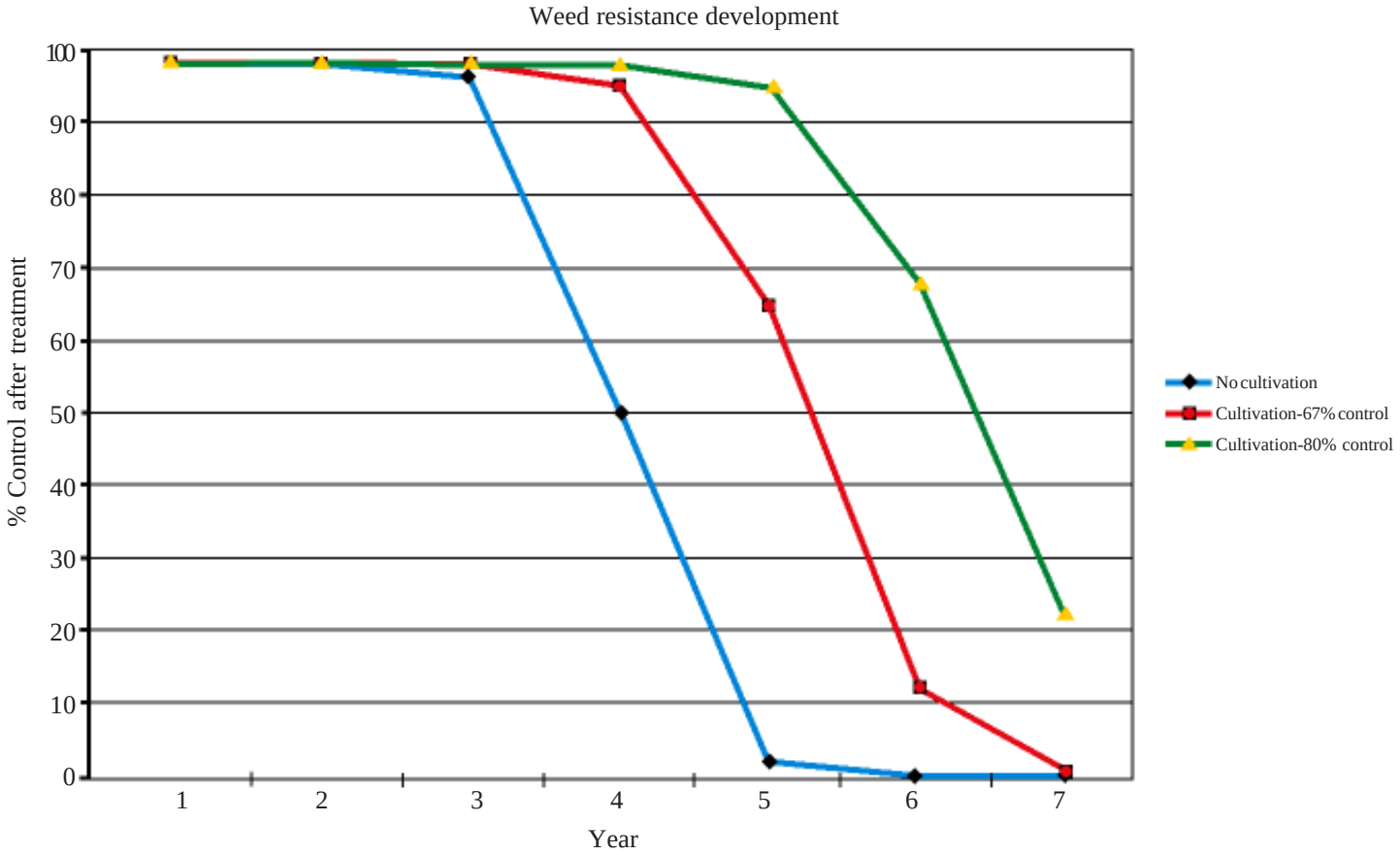


Figure 4. **Hypothetical loss of weed control due to herbicide resistance in a field receiving annual applications of a herbicide. Cultivation slows but does not prevent an increase in the resistant weed population. The model assumes a starting population of one resistant weed per 100,000 susceptible weeds.**

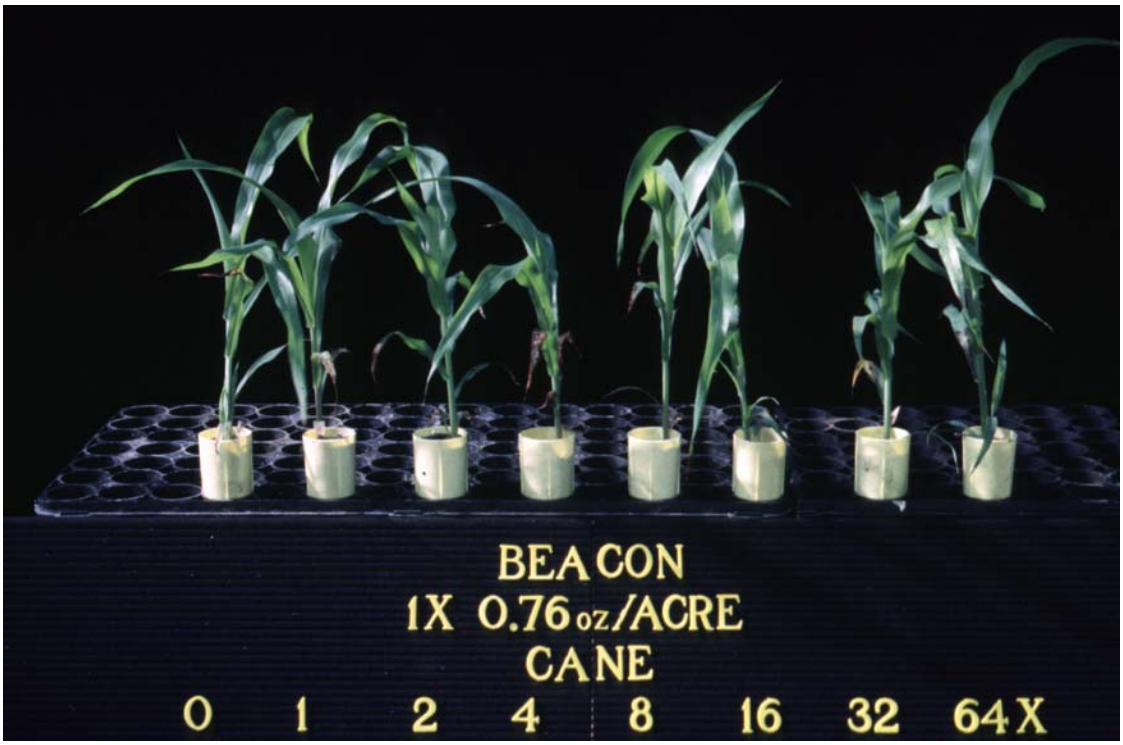


Figure 5. **Herbicide resistant plants can often resist high doses of a herbicide. This shattercane biotype is not affected by a rate 64 times that recommended for Beacon (ALS inhibitor). Photo courtesy of Dan Anderson.**

How do I know if I have herbicide-resistant weeds?

Herbicide resistance is not dependent on the environment or growth stage. Resistant plants will survive the herbicide treatment even under ideal environmental conditions (see *Figure 5*). The earliest indication of resistance will be surviving plants (escapes) in the middle of a group of dead plants. In most cases, herbicide-resistant plants are only noticed after they comprise a large percent of the weed population in a field. Inadequate weed control does not necessarily mean that herbicide resistance has developed. Factors such as unfavorable environmental conditions, inadequate spray coverage, and oversized plants can cause herbicide failure. If weeds have ben treated with the same herbicide site of action for several years in a row and herbicide failure occurs, the surviving plants likely are resistant. If you suspect herbicide resistance, contact your local Extension office.

Can I prevent resistant weeds from becoming a problem?

The best defense against herbicide resistance is to avoid continuous selection for herbicide-resistant weeds. Using herbicides with multiple site of actions during the same year and/or rotating herbicides with different sites of action each year, rotating crops, and cultivation will help reduce selection pressure. Careful inspection of fields for weed escapes and record keeping will provide clues on possible herbicide-resistance.

Practices that reduce the chance of developing herbicide resistant weeds are more effective if used together. For example, crop rotation is less effective at deterring resistance if the herbicide site of action is not rotated as well. ALS-resistant shattercane developed in one field that was in a corn-soybean rotation, yet treated with the same herbicide site of action (but different herbicides) in each crop. Combining strategies to prevent herbicide-resistance has been successful. Farmers who rotated crops, used less atrazine, cultivated, and did not apply manure to their fields had fewer triazine-resistant weeds than farmers who did not rotate crops and relied on atrazine alone. The manure probably contained triazine-resistant weed seed.

What do I do about resistant weeds in my fields?

Early detection of herbicide-resistance is critical in containing resistance. Once a herbicide-resistant weed has developed in a field, the most important step is to keep that resistant weed from spreading to other fields. Farm machinery is one of the main mechanisms for spreading herbicide-resistant weeds from one field to another. Stalk choppers, cultivators, combines and other machines should be cleaned before leaving a field. Since combines can be difficult to clean, the weediest fields should be harvested last, if possible, and the combine thoroughly cleaned before storage. Cultivation and crop rotation are other means to contain herbicide-resistant weeds. *Figure 4* illustrates how cultivation can reduce, but not stop, the buildup of resistant shattercane when Beacon was applied each year.

Switching to another site of action is an effective way to contain herbicide-resistant weeds; however it should be accompanied by methods to prevent resistance. For example, when waterhemp developed resistance to the triazines, some farmers switched to ALS-inhibitors. After several years of applying just ALS-inhibitors, the triazine-resistant waterhemp developed resistance to the ALS-inhibitors (multiple herbicide resistance). The ALS- **and** triazine-resistant waterhemp is a concern since it eliminates the use of two or more herbicide families.

Are herbicide-resistant weeds different from their susceptible counterparts?

Other than the herbicide-resistant factor, no other differences have been detected. Some herbicide-resistant weeds do not compete as well as their susceptible counterparts, but these differences are minor.

Why do we hear more about herbicide-resistant weeds?

Herbicide-resistant weeds are spreading and new weed species are developing resistance. Triazine-resistant kochia was first identified in Nebraska in 1979 and now is present in all but five counties. ALS-resistant waterhemp was first reported in one or two counties and now covers the eastern half of Nebraska. ALS-resistant shattercane was first found in Nebraska and Kansas in 1996. In 1997, ALS-resistant sunflower was reported in Kansas and suspected in central Nebraska. The development and spread of herbicide-resistant weeds is due in part to repeated use of the same herbicide site of action year after year. Education on herbicide site of action must be improved.

Will herbicide-resistant weeds take over fields?

The answer to this question depends on whether approaches to contain and prevent herbicide resistance are implemented. In the past 20 years, herbicide-resistant plants have proliferated through the repeated use of very popular herbicides. If the same herbicide site of action is used each year, the trend of more herbicide resistance in weeds will likely continue. By exercising various strategies such as using more than one site of action to kill weeds, rotating crops, cultivating, and implementing other integrated weed management methods, this trend will likely be slowed and the impact of herbicide resistance will be diminished.

Herbicide resistance is a battle that can be won as long as we choose to fight it.

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